Innovative Spaces for Mathematics Education with Technology

Introduction: Innovative Spaces for Mathematics Education with Technology

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The idea of this book arose from research encounters occurred during a past ICTMT Conference: the International Conference on Technology in Mathematics Teaching. The ICTMT Conference, which is now moving to its 13th edition, has a strong commitment to promote technology in mathematics education for improving the quality of teaching and learning by effective use of technology. In recent years, international research in mathematics education has offered a range of theoretical perspectives that attempted to provide different and interrelated frames and viewpoints to the study of use and role of digital technologies in/for teaching and learning mathematics (e.g. Hoyles & Lagrange, 2010; Drijvers, Kieran, & Mariotti, 2010; Drijvers, Tacoma, Besamusca, Doorman, & Boon, 2013). But still, the integration of technology in the didactical practice, far from becoming a reality in the mathematics classroom, is a crucial issue of this discourse subjected to various lines of flight and critical interpretations.

Today, in particular, part of the discourse sheds some light on change and transformation implicated for the classroom practice of the mathematics teacher in the digital era (see Clark-Wilson, Robutti, & Sinclair, 2013). Other part mainly focuses on the influential affordances of software environments or devices (for example, Hegedus & Moreno-Armella, 2008; Arzarello, Ferrara, & Robutti, 2012;

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Calder, 2015), as well as on the ways that technologies affect or even change the nature of the mathematical objects and relations (e.g. Rotman, 2008; Sinclair, de Freitas, & Ferrara, 2013). Generations of research on new technologies in mathematics education have been discussed (Sinclair, 2014; Drijvers, 2015). In this respect, are underlined the massive changes in the nature of the physical interactions with digital technologies, from the entirely alphanumeric hegemony of the keyboard to the even continuous movement with the mouse, to touch and haptic experiences, which put forward more direct action and gesture that come to replace the mouse and keyboard, and how these new forms of interaction make very different demands on the body but also on the mathematics, eventually implying new ways of sensing and making sense, a new kind of sensory politics at play in the mathematics classrooms (cf. chapter six in de Freitas & Sinclair, 2014).

More recently, researchers have started drawing attention to how the technology might offer new ways of engaging with mathematical thinking and engender new kinds of mathematical experiences for learners (e.g. Santi & Baccaglini-Frank, 2015; Calder & Campbell, 2016; Hegedus & Tall, 2016; Sinclair, Chorney, & Rodney, 2016). Student interactive engagement with mathematics, motivation and level of interest have also been part of the wide landscape (Attard & Curry, 2012; Lange & Meaney, 2013).

However, when the research lens is trained on educational research, the emphasis can shift away from practice and activity, from task design, from the role of the teacher but also, and more importantly, from the conceptual or empirical *positionings* of the researchers (see Herbel-Eisenmann, Wagner, Johnson, Suh, & Figueras, 2015) and the implications for their particular ways of speaking about research on technology. Beyond the fact that the nature of these positionings is revealed to vary immensely in the literature, Herbel-Eisenmann and colleagues underline that often, the sources from which people draw as they position each other are not explained well.

This fuzziness further complicates the relationship between positioning and storylines that are offered to readers in discourse, and entails a social meaning that depends upon the positioning of the speaker(s) as soon as this is seen as a product of the social force implicated in any communication action. Deepening the discussion, we might reconsider how the widespread use of technologies in everyday life has forged changes in the ways in which people interact and communicate beyond how they know, implying in turn a wide open range of possibilities for ways of positioning.

This challenging view is typical of current research in our field and the chapters in this book attempt to face such a sociological change drawing on the issue of innovation regarding researching about technologies and mathematical practice. It is also concerned with the reason under our choice, as Editors of the book, of talking about *spaces*. The image of space grasps here a vision of how the world looks to an individual and how the individual lives in the world. The spaces we take into account here are those where the authors of the different chapters live their specific perspective on innovation and technology at a meta-level, which is that of the particular researcher who is culturally positioning herself with respect to a certain perspective.

Therefore, the readers of the book can discover and recognize ideas and meanings of innovation as they emerge from the entanglement of the researchers with the mathematical activity, the teacher training program or practice, the student learning and engagement, or the research method that they are telling stories about. The multiple views that arise from this book have to be considered as a rich bundle of heterogeneous theoretical or empirical positionings of research, being them philosophical, instrumentalist, cognitive, technological or of other kind.

Starting a journey through the text, the reader will first encounter an opening scenery (Chap. From Acorns to Oak Trees: Charting Innovation Within Technology in Mathematics Education, by Carreira and colleagues) that recalls the ideas coming from the past ICTMT conferences, launching the delicate and subtle issue of how we have been used to speak of innovation within technology in mathematics education research, highlighting the few key innovations that have been seeded and taken root within the community of participants through the history of ICTMT.

After this scenery, the book is split into three parts that breach into spaces as explicit ways of positioning and telling stories about the teaching and learning of mathematics with technology.

The first part (*New spaces for research*) consists of three different chapters that advance fresh theoretical and methodological positionings about innovative ways of learning. Sinclair and Coles (Chap. Returning to Ordinality in Early Number Sense: Neurological, Technological and Pedagogical Considerations) propose to relate inclusive materialism and enactivism in concert with recent findings of neuroscience in order to think of new methodological possibilities for thinking of the importance of ordinality in the early learning of number and how this might be fostered by a new technology. De Freitas and colleagues (Chap. The Coordinated Movements of a Learning Assemblage: Secondary School Students Exploring Wii Graphing Technology) position from the perspective of assemblage theory to study how human bodies collaborate and assemble with technology when exploring mathematical ideas, offering the idea of learning assemblage to analyse data less in terms of tool use and more in terms of the affective force of the technology. Robotti and Baccaglini-Frank (Chap. Using Digital Environments to Address Students' Mathematical Learning Difficulties) centre their positioning on literature mainly coming from cognitive psychology, which helps address the issue of learning in relation to students with learning difficulties and to software that might promote new learning in this situation. Therefore, the context is different among the three chapters, but they share common interests in how specific positionings make different demands on the body and on mathematics.

The second body of three chapters (*New technological spaces*) contributes to the discourse with attention mainly drawn to affordances and innovative uses of new digital technologies. In this case, the positionings of the various researchers have in common their tentative dwelling upon implications and benefits of the technological environments. Through a comparative research, the instrumental positioning of Thomas and colleagues (Chap. Innovative Uses of Digital Technology in Undergraduate Mathematics) centres on the new use of digital environments in first

year mathematics courses at the university, in order to tackle with possible discontinuities in the transition from secondary to tertiary education. Concerning the duo of artefacts designed by Maschietto and Soury-Lavergne (Chap. The Duo "Pascaline and e-Pascaline": An Example of Using Material and Digital Artefacts at Primary School), innovation is unfolded along two dimensions: the emergent relationships between the digital and the physical in the duo, and the possibility of integrating the digital in primary school in a way that supports teaching and learning practices. Weigand's contribution (Chap. What Is Or What Might Be the Benefit of Using Computer Algebra Systems in the Learning and Teaching of Calculus?) positions from the side of previous research on computer algebra systems and tries to deal with a new understanding and vision of the benefits of using this technological environment in the mathematics classroom, through the development of a competence model.

The third part of the book (*New spaces for teachers*) only includes two chapters that both shift the focus of our discourse specifically on teaching and take strong positionings on teaching as an activity. Kynigos (Chap. Innovations Through Institutionalized Infrastructures: The Case of Dimitris, His Students and Constructionist Mathematics) suggests to reflect on the potential for innovation made possible by connecting different kinds of innovation, and to re-think constructionism as an innovative activity that is rich in opportunities for meaning making in the era of large portal and the social web, through an example of constructionist mathematical activity by one teacher and his class using portals. Despite the widespread availability of new digital expressive and communicative possibilities, Tabach and Slutsky's positioning (Chap. Studying the Practice of High School Mathematics Teachers in a Single Computer Setting) differs from Kynigos', calling attention for the specific situation in which students do not have access to the digital but only the classroom teacher is equipped with a computer and data projector, therefore, pointing out the need for a new—for this reason, innovative—instrumental framework able to address and support teacher practice adequately in such situations.

The mosaic of the varied research that features this book is completed with the closing scenery (Chap. Digital Mazes and Spatial Reasoning: Using Colour and Movement to Explore the 4th Dimension). De Freitas affords to propose new inventive learning about spatial reasoning and spatial sense in four dimensions with digital maze technology, pointing to possible directions for future research on innovative approaches to mathematics thinking.

With this panorama in mind, we hope to leave the reader with a flavouring will for unfolding and unveiling—possibly, traversing—multiple dimensions of the spaces discussed throughout the book. In a way similar to how technology prompts interaction and how the teacher can create her own space for interaction, we hope that this book might contribute to current discussions on mathematics education with technologies offering researchers and readers spaces for communication and comparison and prompting them to create their own new spaces, rich in positionings and stories.

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